Technical Article Nº 1

Improving vineyard resilience: adapting to extreme heat and drought conditions in dry farming

The Mediterranean region is experiencing some of climate change's most intense effects of on European agriculture, including more frequent extreme heat, droughts, loss of biodiversity and increasing water needs. This is particularly concerning for perennial fruit crops such as grapevines, which cover substantial areas and are increasingly affected by these changes. Farmers are adjusting their practices to cope, but many of these solutions remain confined to specific regions or agricultural sectors. The EU-funded [CLIMED-FRUIT](#) [1] project is working to bridge this gap by collecting and sharing innovative, climate-adaptive practices from various European agricultural operational groups (OGs) to enhance resilience and promote effective climate change adaptation and mitigation.

Increased temperatures and unpredictable rainfall patterns are causing substantial declines in fruit productivity and quality. Sustainable practices and climate-adaptive technologies, including shading nets, foliar applications, and drought-resistant varieties, are essential to counter these effects.

This article presents a non-exhaustive list of experimental results from projects carried out across Europe and identified in the framework of the CLIMED-FRUIT project.

Shading nets in vineyard management

Shading nets are highly effective tools for mitigating the impact of extreme heat, reducing solar exposure and, thus, sunburn risk, on grape clusters. While installation can be costly, shading nets provide dual benefits by protecting against hail, which is increasingly common with changing weather patterns.

The presence of netting greatly reduces the amount of photosynthetically active radiation (PAR/RAP*). This reduction is systematically proportional to the degree to which the netting is obscured (Fig.1 below).

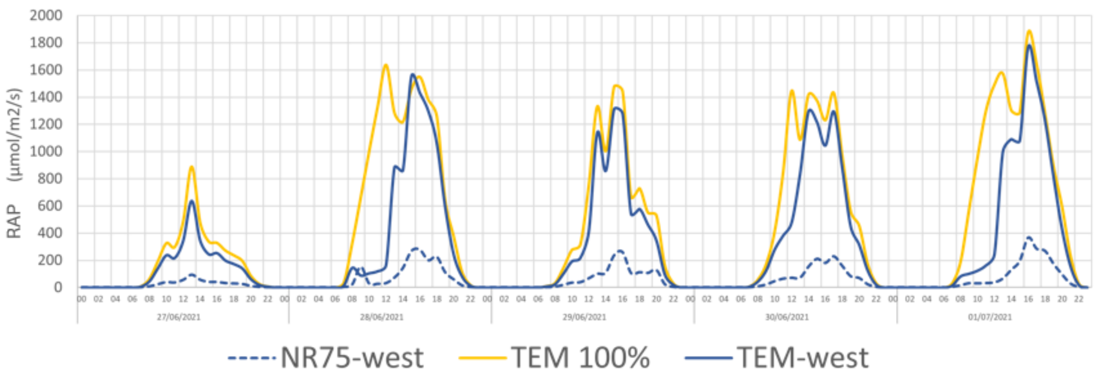

Fig. 1: Comparison of radiation with and without a net. Sensor placed under a black 75% blackout net installed on the west face of the canopy (NR75-west). Sensor placed above the row in an open area (TEM 100%). Sensor placed in the foliage on the west side (TEM-west). *RAP- Rayonnement photosynthétiquement actif (originally in French).

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Shading nets also delayed the grape ripening process by five days, which aids in achieving optimal wine quality under higher temperatures. The effects on the surface temperature of the bunches (when the ambient temperature is at its highest) are systematically significant: up to 4°C less thanks to the nets. The project also demonstrated a ~20% increase in assimilable nitrogen in grape musts, although phenolic compounds in red wines decreased slightly in some cases. Vineyards with nets saw altered berry composition, including lower sugar levels and higher acidity, which benefits wine stability and flavour. Additionally, as far as water status is concerned, the vines under netting are less stressed than the control when the water deficit is pronounced (δ13C>-25). The protection of nets against hail is also an advantage that can be highlighted [2].

Furthermore, net colour can influence berry parameters and wine production [3]. White nets effectively decreased berry temperatures under direct sunlight and optimised sugar accumulation in the grapes (Fig. 2). This finding points to the potential of shading nets in adjusting vineyard microclimate, offering flexibility to growers in mitigating specific stressors. The quality and resilience of grape production improve thanks to these adjustments, aligning with the demands of modern viticulture.

Name	Plot	Shading %
CON	Control	0
WHT	White	30
LGR	Light Green	8
DGR	Dark Green	19
BLK	Black	26

Fig. 2. RESILVINE project, Ferghettina farm. Table shows the net colour and shading percentage.

Foliar applications to mitigate stress

Foliar applications have become increasingly adopted as a strategy to combat drought and heat, utilising substances such as kaolin clay, salicylic acid and abscisic acid to protect vines against extreme conditions.

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Fig. 3. Use of kaolin in a Marselan vineyard (Bodegas Enguera)

- **Kaolin**: A naturally occurring clay mineral, kaolin creates a reflective layer on vine leaves that reduces water loss through transpiration and shields against UV light, which can decrease leaf and fruit temperature by up to 5°C. Trials in Spain [4] (Fig. 3) found that 3% and 6% kaolin-treated Marselan grapevines exhibited improved tannin levels, colour intensity and aromatic complexity — key indicators of wine quality. Kaolin was sprayed twice, at pre-veraison and three weeks before harvest.
- **Salicylic Acid (SA)**: Known for activating plant defence mechanisms, salicylic acid enables vines to better withstand environmental stresses. A study in Egypt [5] found that two applications with 3mM SA in April and May could be used as a management practice for improving water stress tolerance.
- **Abscisic Acid (ABA)**: As a plant hormone central to drought response, ABA helps vines conserve water and adjust growth patterns during water scarcity. Applied during drought periods, ABA can effectively modulate vine physiology to minimize water loss, maintaining vine health and yield stability. Weekly applications of 1 mM ABA from bud break to harvest improved grape leaf tolerance to elevated solar UV-B (reducing oxidative damage) [6].

Soil cover management

Dry farming combines various techniques that limit the need for irrigation, improving soil health and resilience, especially in drought-prone regions. Key methods include mulching, cover cropping and utilising drought-tolerant plant varieties, each tailored to enhance soil moisture retention and reduce overall water needs.

- **Cover cropping**: Cover crops planted between vine rows after harvest are crucial for improving soil water storage. An experiment conducted in vineyards in northwestern Italy [7] evaluated cover cropping, showing that late spring cover crop termination increased soil moisture retention by up to 10%, supporting vine water needs during dry periods. Different cover crop types yielded various results: cereal-based cover crops increased grape sugar content, while legume-based cover crops enhanced acidity and available nitrogen. This approach improves water retention

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and supports other ecosystem services, such as soil carbon sequestration, pollination and erosion control.

- **Mulching**: Different types of organic and bio-based mulches, such as wood chips, green waste compost, straw and woven cellulose, have proven effective in reducing soil temperature, limiting evaporation and conserving moisture. Mulching also enhances soil structure, microbial activity and carbon storage. In particularly dry seasons, mulched vineyard soils retained up to 20% more moisture than unmulched soils, reducing irrigation needs and promoting healthier root zones.

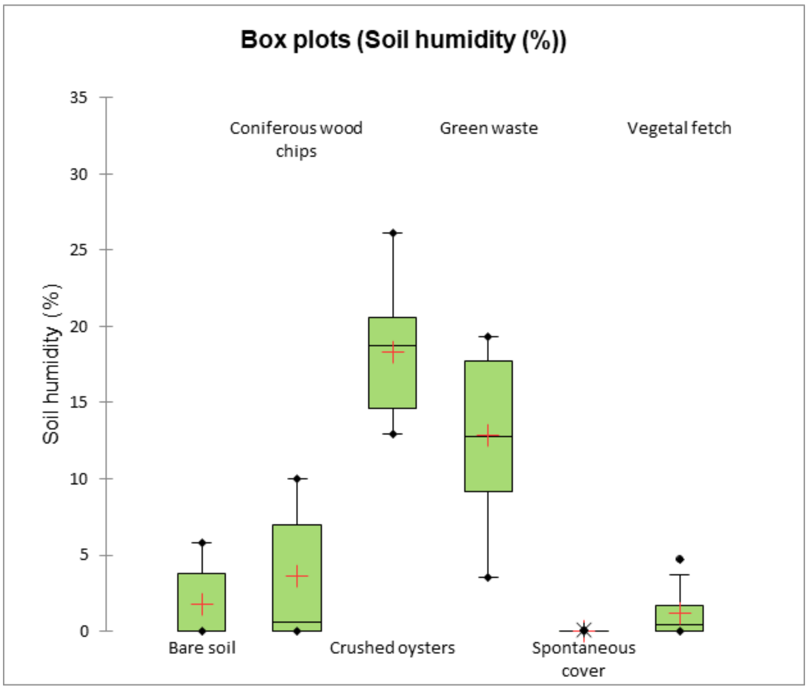

Fig. 4: Soil humidity (%) at 15 cm depth for different exogenous dead mulches under the vine raw, 2023 vintage. Bars from left to right: bare soil, crushed oysters, coniferous wood chips, green waste, spontaneous cover, vegetal fetch

Seasonal weather trends heavily influence the efficiency of dry farming techniques. While beneficial in water-scarce years, these practices require careful adaptation to current climatic conditions to maximize soil water retention and improve grapevine stress tolerance.

Selection of drought-tolerant rootstocks

Choosing drought-resistant varieties and rootstocks is a cost-effective, sustainable strategy for enhancing vineyard resilience. Certain grapevine rootstocks are naturally adapted to drought conditions, exhibiting deep-rooted systems, efficient water uptake and heat tolerance, which are essential traits in regions prone to dry spells. Widely used drought-resistant rootstocks include 110 Richter, 140 Ru, 44-53M and SO4, each selected for its high water extraction capacity and ability to minimize water loss. These rootstocks

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influence vine canopy growth and water-use efficiency, enabling consistent production even in arid conditions.

Conclusion

The increasing frequency and intensity of climatic hazards require a multi-faceted approach to vineyard resilience. By integrating shading nets, foliar applications and dry farming practices and selecting drought-tolerant varieties, vineyards can effectively adapt to rising temperatures and prolonged droughts. These practices improve vineyard resilience and productivity and contribute to the sustainability of wine production in the face of climate change.

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